Table 2

Comparison of the dimensions of the first marginal tooth in *Siphonaria zelandica*, *Trimusuclus reticulatus* and *Gadinalea nivea*. All sizes in μm.

	Whole length cusp tip to base edge	Base length	Base width	Cusp length (unworn)	Cusp width
Siphonaria zelandica	41	32	20	29	8
Trimusculus reticulatus	16	5	6	13	3
Gadinalea nivea	15	8	5	10	3

in the radula sac though its tip may be seen through the opening. In *T. reticulatus* the radula probably plays a bigger role in the drawing in of mucus than in *G. nivea* but in both, the ridged surface of the odontophore appears the most important.

GUT AND FAECAL ANALYSIS

Food taken in has been studied from the consolidated faecal pellets and also from the gut contents. When animals preserved in Bouins are dissolved in 15% NaOH all parts are digested except for the radula and frequently the mid and hind gut contents which remain as a continuous string consisting of mucus and food particles. The majority of the identifiable particles are diatoms. Sponge spicules and odd small ecdysed limbs or limb segments from crustacean larvae are also present. There is no evidence of whole small crustacea being taken in, for example from larvae freshly settled on the substrate. The diatoms in the gut contents studied here have been identified by Dr. F. J. Taylor as mostly attached species. However it appears that these are individuals which have been washed from the rock surface. Those diatoms at the front of the intestine, where little digestion can have occurred,consist of both empty and full frustules indicating that both living and dead diatoms were trapped, and that these were therefore washed-off specimens. Only very small rock particles were ever found and were rare. Radula teeth were also found along the gut string showing that the radula is used actively during feeding. However, more important was the fact that the teeth showed very little wear. By comparison the terminal teeth of *Siphonaria zelandica* showed a reduction in the length of the main cusp from 29 to 19 μm, due to wear. It is therefore clear that the delicate teeth of *Trimusculus reticulatus* scarcely abrade the substrate although they are used to "graze" food bearing mucus from the mantle cavity.

FEEDING RATES

Particle removal experiments were performed in two types of apparatus. One was the same apparatus that was used for *Gadinalea nivea* (Walsby *et al.*, 1973) and the other, easier to run for long periods, a simple closed circuit recirculation system (Figure 3), in which the sea water of known particle concentration was circulated by means of a small air lift pump having a siphon overflow. This allowed water to be delivered into the animal chamber in small surges simulating wave action. Cultured *Dunelliella salina* was used for the food particles. Figure 4 shows a typical decline in particle concentration. The bars indicate observed periods of odontophore protrusion and withdrawal. After these periods, the samples always showed a reduced particle count. Control experiments showed either little

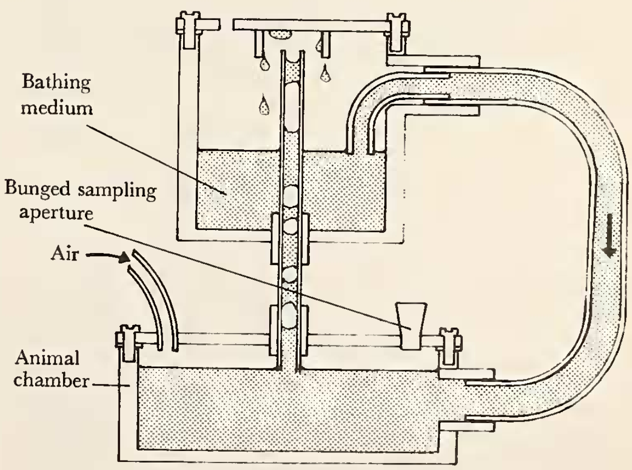

Figure 3

A closed circuit system for circulating a small volume of medium with surging water movements

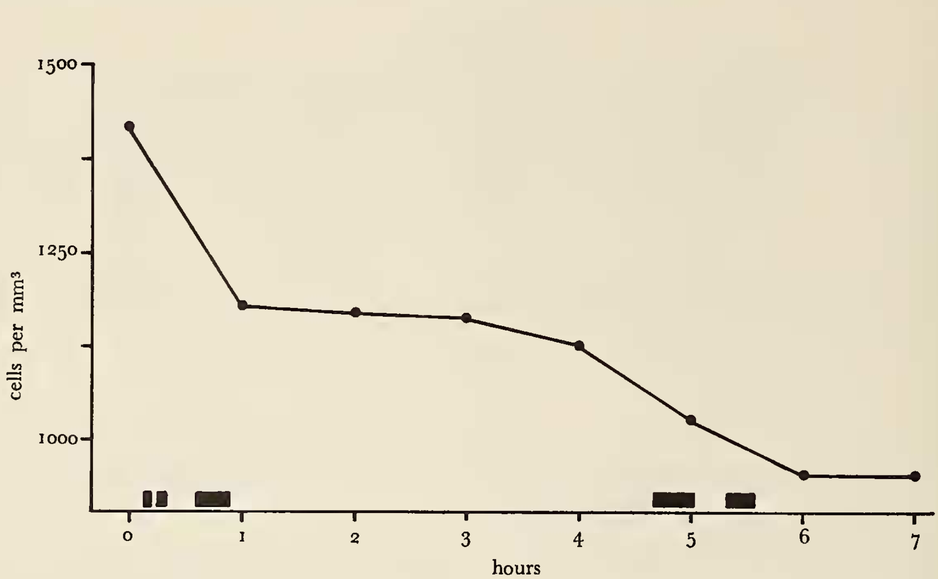

Figure 4

Removal of algal particles from suspension by *Trimusculus reticulatus* in a closed circuit recirculating system. Bars indicate observed periods of odontophore protrusion

change or a slight increase in the particle count due to cell division.

Single animals were tested and the changes in the particle concentration followed by withdrawing small samples for estimation on a haemocytometer slide. In the typical example shown (Figure 4), the apparatus working volume was 170 cm^3 of concentrated *Dunelliella salina* medium 1.4×10^6 cells per cm^3.

DISCUSSION AND CONCLUSIONS

The method of food collection of *Trimusculus reticulatus* is similar to that of *Gadinalea,* relying on the viscosity of mucus secreted from the anterior mantle lip, dorsal surface of the head and front of the foot to trap suspended particles. The food-laden mucus is ingested by odontophore protrusion and withdrawal, in which the tip of the small radula, but more especially the ridged surface of the odontophore, are important in encapturing the mucus. Thus these animals retain the similarity with their relatives, the Siphonariidae, of odontophore protrusion to obtain food although beyond this habit and functional morphology are quite different. By comparison, the radula and its teeth are small and the radula is not exposed and inflected as is that of *Siphonaria.* Whilst capable of movement they are sedentary in sites where surface algal growth would be extremely low or absent. They are found in wave exposed sites of high water turbulence but sheltering in depressions and crevices from direct wave attack. They suspend from the roof and side walls of caves and overhangs where sedimentation will be low. Haven (1973) suggests, without evidence, that *Trimusculus conica* may obtain sufficient food by grazing the substrate region around the head like *Hipponix antiquatus.* However *Hipponix* has modifications for sensing and encapturing particles fallen from suspension (Yonge, 1953) and inhabits sites where sedimentation will occur quite distinct from the habitat of *T. reticulatus* (Yonge, 1960). One of the specimens of this study adhered to a vertical plastic wall of the aquarium for over a year during which it showed continued shell growth. On this smooth surface there was negligible settlement of particles, and known grazers all died after about two months in the same tank in this aquarium dark-room.

The ability to efficiently remove particles has been shown from experiments in which decrease in the bathing medium particle concentration coincided approximately with observed feeding periods. Using *Dunelliella salina* as the suspended food material, the accumulation of particles in secreted mucus could be seen by the bright green tainting about the sites of mucus production and this tainted mucus was later removed during bursts of odontophore protrusion.

Both *Trimusculus reticulatus* and *Gadinalea nivea* are found closely aggregated in large numbers. As they move very little, presumably they have a low energy demand. However, the size of the colonies would indicate that the feeding method was efficient although it, and therefore the distribution of the animals, is probably limited by the physical conditions of particle capture. These will depend on the particle size and mass, the particle velocity (= water current speed) and the viscosity of the mucus.

SUMMARY

In life studies of the marine pulmonate limpet *Trimusculus reticulatus* show it to be essentially sessile. It is found on exposed shores and lives in the inverted position on the roofs of caves and crevices. The foot dimensions show adaptation to immobility on exposed shores. The animal feeds on current-borne food particles which adhere to mucus secreted from the mantle lip, top and sides of the head and front of the foot. This is ingested by odontophore protrusion. There is no jaw, only vestigial salivary glands and the radula is very small with delicate minute teeth. However the odontophore is quite large and has a markedly ridged surface for mucus ingestion. Radula comparisons are made with related species. Particle removal from suspension was demonstrated in apparatus where natural water movements were simulated.

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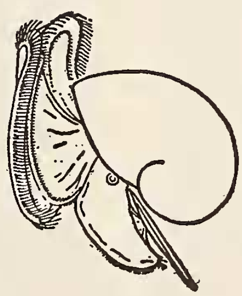

Reproduction in the Giant Octopus of the North Pacific, *Octopus dofleini martini*

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(1 Plate)

INTRODUCTION

There have been several laboratory studies of reproduction in octopods. *Octopus joubini*, for example, has been reared through four consecutive generations (Thomas & Opresko, 1973), and the eggs of *Hapalochlaena maculosa* have been raised through to the subsequent generation (Tranter & Augustine, 1973). The young also have been described of *Octopus ocellatus* (Yamamoto, 1941), *Paraledone nigra* (Rees, 1954), *Eledone cirrhosa* and *Eledone moschata* (Rees, 1956), *Octopus vulgaris* (see for example Vevers, 1961 and Itami *et al.*, 1963), *Octopus briareus* (Messenger, 1963 and Wolterding, 1971) and *Robsonella australis* (Brough, 1965), to cite some examples.

Octopus dofleini (Wulker, 1910) is the large octopod inhabiting the waters of the North Pacific. According to Pickford (1964), there are at least three subspecies: *O. dofleini apollyon* (Berry 1912) from the Pacific far North, *O. dofleini dofleini* (Wulker 1910, emend. Sasaki, 1929) from the temperate western North Pacific, and *O. dofleini martini*, Pickford, 1964, which inhabits temperate waters of the eastern North Pacific. In Japan, Okubo (1973) made a detailed study of the eggs and juveniles of the Western Pacific subspecies, *O. dofleini dofleini*. The only previous report on the behaviour of young of *O. dofleini martini* was a recent description in "Oceans" of the emergence from the egg of juveniles (Ruggieri & Rosenberg, 1974). The opportunity to further study life history and behaviour arose in March, 1973, when the Vancouver Public Aquarium acquired a mature female *O. dofleini martini*, a mature male already being in their possession at that time.

MATERIALS and METHODS

The adult octopuses were mated in a 2782-liter fiberglass tank on March 15, 1973. The female was placed in the tank on March 14, and the male on the following morning. After mating, they were separated and the female was transferred to a 265-liter fiberglass brooding tank. Tanks were supplied with running sea water pumped directly from nearby Burrard Inlet and passed through a series of sand filters. For the duration of the study, the female was offered frozen herring (*Clupea* sp.) and large, live cancer crabs (*Cancer magister* Dana, 1852) as food, both of which were generally accepted.

Temperature, salinity and pH of the water were measured throughout the spawning, brooding and hatching periods. Table 1 shows the range of each during the three periods.

Beginning on July 26 and every few days thereafter, a small quantity of eggs was removed and preserved in buffered formosaline. The figures in Table 2 are averages based on the measurements of a sample of 20 animals.

After hatching, the young were transferred into tanks ranging from 38 to 114 liters. The mouth of the outflow tube was expanded by attaching a styrofoam cup with a 70 mm diameter. Plankton netting (mesh size approximately $\frac{3}{4}$ mm) was stretched across the mouth of the cup thereby preventing the juveniles (and their food) from being swept through the outflow. The inflow tube directed water past the mouth of the cup to prevent animals from becoming entangled in the netting. The water flow in the tanks was approximately one liter per minute. Juveniles were offered a variety of foods including crushed egg yolk,